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SCIENCE AND INDUSTRY IN INDIA[1]

By the late Lord RUTHERFORD OF NELSON

During the past fifty years, the British Association for the Advancement of Science has been invited on many occasions to hold its meetings overseas. Four times it has journeyed to Canada (Montreal, 1884; Toronto, 1897; Winnipeg, 1909; Toronto, 1924), twice to South Africa (1905, 1929), once to Australia (1914). This policy of the association of arranging occasional meetings in our dominions has proved an unqualified success. These overseas visits have had a marked influence on the progress of science throughout our commonwealth and by personal contacts have helped much to promote mutual understanding and cooperation between our peoples.

The visit of a representative group of scientific men to our most distant dominions in 1914, in itself an outstanding event in the history of the association, was rendered even more notable by the dramatic circumstances under which the meetings were held, for the arrival of the party in Australia coincided with the news of the outbreak of the great war. Any one who like myself took part in the meetings in Australia and New Zealand in those troubled but stirring times can ever forget the warmth of our reception. We were privileged to witness that wonderful response of the peoples of these lands to the call of danger—a response which we know grew ever greater with the need.

It has long been the wish of the British Association to hold a meeting in India, and difficulties of time and climate alone have stood in the way of its realization. It has been found most convenient for the overseas

[1] Presidential address before the Indian Science Congress Association, prepared by Lord Rutherford before his death and presented to the congress meeting in Calcutta on January 3. This is the first part of the address which contains two other sections, one on Industrial Research in Great Britain and one on Transmutation of Matter.

visits to take place in the summer months, but such a time is quite unsuitable for India. This difficulty would be in part surmounted if a representative party of scientific men could obtain leave of absence from their duties to visit India during the cold weather.

The celebration of the silver jubilee of the founding of the Indian Science Congress Association offered a suitable occasion for such a visit, and arrangements have been made through the two associations to hold a joint meeting in India. I gladly accepted the invitation of the two bodies to preside over this combined meeting. I feel it not only a great honor but a great privilege and responsibility to be asked to fill this post on such a historic occasion. This visit of the British Association to your shores is a symbol of our desire to extend the hand of greeting and fellowship to our sister society and also individually to our co-workers in science in India.

While science has no politics, I am sure it is of good omen that our visit happens to fall at a time when India is entering upon a new and important era of responsible cooperative government, in the success of which both our countries are deeply concerned.

On behalf of the British Association, I extend to the Indian Association our warmest congratulations on this the twenty-fifth anniversary of its foundation and our sincere wishes for its continued success. We recognize that your association, both in its constitution and its aims so closely resembling the British Association, has proved of great service to the progress of science throughout India. Founded at a time when the universities were becoming centers of original research, it afforded to a widely scattered scientific community a much-needed common meeting ground for the discussion of scientific problems. It helped also to bring to the attention of the interested public the importance of science and of the scientific method in national development. I think it can be safely stated that the success of the meetings of the Indian Association in no small degree influenced the later foundation of specialist societies in India, for example, the Chemical Society and Physics Society.

On such an occasion as this, we must not forget to do honor to those who were largely instrumental in founding your association and in guiding its infant steps. I would refer in particular to Professor Simonsen, Professor McMahon and your first president, Sir Asutosh Mukherjee. The association owed much in its early days to the friendly support and encouragement so freely given by that premier Indian Society, the Royal Asiatic Society of Bengal, of which I am proud to be an honorary member.

In earlier days in India, research was largely confined to the great scientific services, initiated and maintained on a generous scale by the Indian Government, for example, the Survey of India, the Geological Survey, the Botanical Survey, the Departments of Agriculture and Meteorology and many others. Pioneer work of outstanding scientific importance has been done by all these services. In the short time at my disposal, I can only make a passing reference to a few items of work accomplished, and can mention only a few of the array of distinguished names which have been connected with these great scientific services.

The Trigonometrical Survey of India has a long and distinguished history. The splendid series of geodetic measurements along an arc from Cape Comorin to the Himalayas, made by Everest, was of outstanding importance, and his name is forever associated with the highest peak in the world. As a result of this survey, the deflections of a plumb line, due to the gravitational attraction of the Himalayan range, were determined at different points. A careful comparison of the results of observation with calculation, largely due to the work of Archdeacon Pratt of Calcutta and later of Sir Sidney Burrard, disclosed marked discrepancies, the effect of the mountain mass at a distance being much less than was expected. Attempts to explain these and other anomalies ultimately led to the formulation of a new and important theory of mountain formation known as the principle of isostasy. On this hypothesis, the excess pressure due to a mountain mass is compensated for by a deficiency of matter below its base. This conclusion, which is in accord with extensive gravitational as well as geodetic measurements in India, is believed to be of general application to mountain formation throughout the world.

I may recall that a former distinguished superintendent of this survey, Sir Gerald Lenox Conyngham, is head of the department of geodesy in Cambridge.

The Geological Survey, one of the oldest scientific services in India, has a fine record of work accomplished, and its survey of the mineral resources of India has proved of great value to Indian industry. Among many distinguished names, I may specially mention that of Sir Thomas Holland, a former director, who has done such good work for your country in peace and war. I believe that it was largely due to his energy and scientific insight that the great Tata Iron and Steel Works were begun.

The Department of Meteorology has done much pioneering research and was one of the first to realize the importance of studying the conditions of the upper air by means of small balloons—a subject of ever-increasing importance with the advent of the aeroplane. I have always felt a certain connection with this department, as many of its members are known to me personally. Amongst them is Sir Gilbert Walker, a former director and once president of this association, who did much to improve the Meteorological Service

in India and himself made important original contributions to our knowledge of the southwest monsoon. I may recall that the present distinguished head of the Meteorological Office of Great Britain, Sir George Simpson, was for many years a member of this Indian department.

The study of the botanical riches of India owes much to the work of Roxburgh, Wallich and Prain, and also the explorer and naturalist Hooker, whose work on the flora of British India is known to you all.

In forestry, India has at Dehra Dun probably the finest research laboratory of its kind in the world. We in England owe a debt of gratitude to India in providing us with our distinguished professor of forestry at Oxford, Professor R. S. Troup, and the first two directors of our Forest Products Laboratory, namely, Sir Ralph Pearson and W. A. Robertson.

While in this brief survey I can only mention a few departments out of many, yet I must not omit to refer to the great advances in knowledge due to the Indian Medical Service, so well represented by the pioneer work of Ross on malaria and by Leonard Rogers on cholera and leprosy, researches which gave new hope to the people of India.

In the early days of the Indian universities, attention was mainly directed to teaching and examining the large number of students who presented themselves, and comparatively little attention was paid to research. There were always a few, however, who recognized that the universities had a wider part to play in Indian education and should become centers of research as well as of teaching. Amongst those pioneers who distinguished themselves by original investigations and by the stimulation of others, I should particularly mention Sir Alexander Pedler, Sir Alfred Bourne, Sir Jagadis Bose and Sir Prafulla Ray, and it is of interest to recall that the last three have all been presidents of your association.

As a result of the Curzon Commission on Education in 1904, many of the universities introduced honors courses, and by new appointments and improvements in laboratories stimulated research in science. Excellent well-equipped schools of research have arisen in many Indian universities, where good opportunities are available for the training of potential investigators in the methods of research. The Indian student has shown his capacity as an original investigator in many fields of science, and in consequence India is now taking an honorable part and an ever-increasing share in the advance of knowledge in pure science.

Amongst many workers of distinction, I may specially mention Sir Venkata Raman, Professor Saha and Professor Sahni, each of whom has made outstanding contributions. That premier scientific society of Great Britain, the Royal Society, has recognized the value of their work by election to its fellowship.

We in Great Britain watch with pride this growth of the scientific spirit in India and are pleased to help in any way we can. As an example of our interest, I may recall that Trinity College, Cambridge—my own college—assisted that mathematical genius Ramanugan to continue his studies in Cambridge. He was soon elected a fellow of that college and a fellow of the Royal Society. But for his premature death, it may be said of him, as Newton said of Cotes, that we had known something.

The researches in astrophysics of Chandrasaka in Cambridge were at once recognized by the award to him of an Isaac Newton studentship and later by his election to a fellowship in Trinity College.

As a member of the Royal Commission for the Exhibition of 1851, I would like to refer to some events this year of special interest to India. This commission awards each year a number of overseas scholarships to our dominions as well as senior research studentships open to competition in England by all members of our commonwealth. The opportunity offered by these scholarships to promising investigators from overseas to continue their work in England or abroad has proved of great value to the progress of science. I am proud to remember that I myself was awarded an 1851 scholarship on the recommendation of the University of New Zealand.

It has for some time been the wish of the 1851 Commission to be able to offer one or more of its overseas scholarships for award to students in India. Owing to difficulties of finance, it was only this year that this project was realized. A preliminary committee of selection was set up in India, and the commissioners with whom lay the final choice have appointed Mr. N. S. Nagendra Nath, of the Indian Institute of Science, Bangalore, as the first 1851 Exhibition scholar from India. He has gone to Cambridge to carry out investigations in theoretical physics. For the first time also, an Indian student in Cambridge, Dr. H. J. Bhabha, has been awarded in open competition one of our valuable senior 1851 studentships in recognition of the importance of his researches in theoretical physics. The commission would like to be in a position to allot a second science scholarship to India, but funds are insufficient. The machinery, however, is there and I know that the commissioners would be only too happy to administer a second award if any one in India who is interested in her scientific progress were generous enough to provide the necessary endowment.

While, as we have seen, the universities of India have in later years made substantial progress both in teaching and research in science, yet it must be borne in

mind that still greater responsibilities are likely to fall on them in the near future. This is in a sense a scientific age, where there is an ever-increasing recognition throughout the world of the importance of science to national development. A number of great nations are now expending large sums in financing scientific and industrial research with a view to using their natural resources to the best advantage. Much attention is also paid to the improvement of industrial processes and also to conducting researches in pure science which it is hoped may ultimately lead to the rise of new industries.

It is natural to look to the universities and technical institutions for the selection and training of the scientific men required for this development. In India, as in many other countries, there is likely to be a greater demand in the near future for well-trained scientific men. With the growth of responsible government in India, it is to be anticipated that the staff required for the scientific services in India and for industrial research will more and more be drawn from students trained in the Indian universities. It is thus imperative that the universities should be in a position not only to give a sound theoretical and practical instruction in the various branches of science, but, what is more difficult, to select from the main body of scientific students those who are to be trained in the methods of research. It is from this relatively small group that we may expect to obtain the future leaders of research both for the universities and for general research organizations. This is a case where quality is more important than quantity, for experience has shown that the progress of science depends in no small degree on the emergence of men of outstanding originality of mind who are endowed with a natural capacity for scientific investigation and for stimulating and directing the work of others along fruitful lines. Leaders of this type are rare but are essential for the success of any research organization. With inefficient leadership, it is as fatally easy to waste money in research as in other branches of human activity.

The selection of such potential investigators and leaders is not an easy task, for success in examinations in science is no certain criterion that the student is fitted for a research career. A preliminary training in research methods for a year or two is required to select those who possess the requisite qualities of originality and aptitude for investigation. A system of grants in aid or scholarships to approved students may be required for such postgraduate training. In Great Britain the financial help given by the universities and other educational institutions for training in research is in many cases supplemented by maintenance grants to promising students, awarded by the Department of Scientific and Industrial Research. This system has proved of much value both in developing the research activities of the universities and in providing a supply of competent men both for research in pure science and in industry.

I have so far mentioned some aspects of the scientific work carried out by the universities and government services of India. I am well aware that much attention has also been directed to the need of scientific research in agriculture and in certain industries. A cotton research association has been set up which has given admirable service, while the Indian Lac Institute arranges for investigations in that unique Indian product, some of which are carried out in Great Britain. I am interested to know that an agricultural research council has recently been formed, largely as a result of the findings of a commission of which His Excellency the viceroy was chairman.

While I can not lay claim to have any first-hand knowledge of Indian industries and conditions, yet I may be allowed to make some general observations on the importance in the national interest of a planned scheme of research in applied science. If India is determined to do all she can to raise the standards of life and health of her peoples and to hold her own in the markets of the world, more and more use must be made of the help that science can give. Science can help her to make the best use of her material resources of all kinds and to ensure that her industries are run on the most efficient lines. *National research requires national planning. If research is to be directed in the most useful direction, it is just as important for a nation as for a private firm to decide what it wishes to make and sell. It is clear also that any system of organized research must have regard to the economic structure of the country.* One essential fact at once stands out. India is mainly an agricultural country, for more than three quarters of her people gain their living from the land, while not more than three per cent. are supported by any single industry. A glance at the official review of the trade of India shows that the annual production of wheat has risen since 1914 from about 8.3 to 9.5 million tons, while exports in the same period have fallen from 1.2 million tons to 10,000 tons. In the case of another important food, rice, the Indian production, exclusively of Burmah, has remained fairly steady, varying between 22 and 25 million tons annually, but here also exports have fallen from about half a million tons before the war to about 200,000 tons.

In view of these facts, it would seem clear that, in any national scheme of research, research on foodstuffs has a primary claim on India's attention. Quite apart from improvements in the systems of agriculture used in India, there is a vast field for the application of

scientific knowledge to the improvement of crops, for example, by seeking for improved strains suitable for local conditions, by research on fertilizers and in many other directions. The fact that surplus wheat for export has decreased suggests that the present production is required for home consumption in India. When the permanent schemes of irrigation now in hand bring much more land under full cultivation, India may again wish to take her place in the export market. To do this in the face of international competition, well-planned agricultural research will be essential.

While the character of India's exports has seen many changes in the last hundred years, to-day exports of cotton, jute and tea amount to about 60 per cent. of the total exports of India. Next in importance come oil and seeds, 6 per cent., hides, 5 per cent., and lac 1 per cent. There is no doubt that more scientific knowledge would increase the production of all these things. There is of course the need to make sure that there is a market for such surplus. Of India's staple exports, cotton represents about 20 per cent. of the total value. It is characteristic of Indian cotton that the staple is short and, until the cultivation of better varieties is more general, no competition will be possible with cottons of the American type, and trade must mainly be confined to the Indian market and the far eastern countries. Here there appears to be a wide field for applied research. Good work has been done by the Indian Cotton Committee, which has taken steps to improve the staple and prevent adulteration and intermixture of various varieties. The problem can be approached, however, not only in the seeking of better varieties but in finding uses and methods of treatment for the short staple variety. The importance of research on the cotton itself is well brought home by the results achieved in the United Kingdom. The Cotton Research Association there has found that many of the defects which appear in the finished article can be traced back to defects in the raw material.

Finally, a word might be said concerning the need for research on radio-communication, so important a matter to a large country like India. I do not refer to technical research in transmitting and receiving apparatus but rather to the type of fundamental investigation pursued under the Radio Research Board in Great Britain. These investigations, begun in the early days after the war, have shown that the propagation of radio-waves over large distances is very dependent on the electrical state of the upper atmosphere. It is now established that a number of electrified layers exist in the higher atmosphere which under certain conditions are able to reflect electric waves. The details of this electrical distribution vary considerably with the hour of the day and with the season of the year, as well as with geographical location. Such information, which is of practical importance in the selection of the most suitable wave-lengths for radio-communication, must obviously be secured by research conducted in the country itself. Moreover, it does not seem impossible that such a survey may prove of value in long-range weather forecasting.

There is here then much scope for research in a wide field, which I hope will be pursued vigorously in India. It is pleasant to note that a more promising stage in tackling fundamental radio problems of this character has already been made here by Professor M. N. Saha and S. K. Mitra and their students. The importance of survey work of this kind has already been recognized in other parts of the Empire, where it has received official support and encouragement. I refer in particular to the admirable work in this field by the Radio Research Board of Australia.

SCIENTIFIC EVENTS

THE NEW YORK BOTANICAL GARDEN

THE Board of Managers of the New York Botanical Garden on January 10 received the report of Dr. H. A. Gleason, head curator, officially closing his term as acting director. Since the appointment of Dr. William J. Robbins as director, Dr. Gleason has been serving as assistant director. He stated that the herbarium is exceeded in the number of flowering plant specimens only by the National Herbarium in Washington. In its collections of fungi for study it is exceeded only by the Department of Agriculture and the Farlow Herbarium at Harvard, while in mosses it is probably the largest in the world.

Thirty-one botanists from other cities and countries have engaged in research in the herbarium during 1937. Its contents have been made available to others by the loan of more than 16,000 specimens.

Studies of heredity received special attention during the year. As useful by-products of this research, beautiful new forms of day lilies and many hardy seedless grapes have been developed. Work on the grapes, which have been especially created for culture in New York and other northern and eastern states, has been undertaken in conjunction with the New York State Agricultural Experiment Station at Geneva. About 175 new kinds have been developed, a number of which are deemed suitable for commercial culture.

Other work included studies of diseases of ornamental plants and the preparation of monographs on

certain fungi and flowering plants, including the American nutmegs, verbenas of the world, rotenone-yielding plants of South America and some native aquatic plants and the preparation of hand-books on the ferns of various regions.

Records of the floral displays show that more than 30,000 plants, annuals, were grown in the borders; 1,500 new hybrid tea roses were planted in the rose garden; 8,000 plants of heather and heath were added to the Thompson Memorial Rock Garden, more than a hundred mountain laurels were placed in the woodland background to the rock garden; 1,125 rhododendrons and laurels have been planted in a new rhododendron glade; nearly a thousand new trees and shrubs have been set out to add to the permanent collections. An inventory of the rock garden indicates that more than 2,200 different kinds of plants are being cultivated there, while in the greenhouse there are more than 2,500 kinds of cacti and other succulents, many of which are very rare.

Since late spring the conservatory displays have been eliminated because of the reconstruction of the main range of greenhouses. The collection of begonias, which is housed in the greenhouses on the east side of the grounds, is said to rank as the finest in eastern America.

ELI LILLY AND COMPANY RESEARCH AWARD IN BACTERIOLOGY AND IMMUNOLOGY, 1937

An annual research award of $1,000 and a bronze medal has been offered by Eli Lilly and Company to a young man or woman under thirty-one years of age who has made outstanding contributions to knowledge in the field of bacteriology or immunology while conducting investigative work in a college or university in the United States or Canada. This award is being made to stimulate research activities in young people and to reward meritorious achievement at a time in the life of an individual when recognition means the most.

The recipient of the award is chosen by a committee composed of members of the Society of American Bacteriologists, the American Association of Immunologists and the American Society for Experimental Pathology.

The committee has decided that the 1937 award should be given to Dr. Frank L. Horsfall, Jr., whose investigative work has largely been done in the Medical Schools of McGill University and Harvard University, and in the Hospital of the Rockefeller Institute for Medical Research. The choice of the recipient, however, was not an easy task, because the nominees constitute a group of exceptionally able investigators.

This second award is made in recognition of Dr. Horsfall's work dealing with the rôle of lipids in immunological reactions—work that has played a significant part in the establishment of a new thesis in the field of immunology. It was demonstrated that certain antibodies are lipo-protein complexes, the protein being responsible for the specific features of the antibody while the lipid is concerned with the non-specific secondary properties, that is, those causing precipitation and agglutination. Moreover, it was shown that certain species of animals form antibodies in which lecithin is the principal lipid constituent, while in other species the dominant lipid in the antibody is cephalin. This work was extended to demonstrate that lipids are readily and selectively adsorbed by antigen-antibody combinations, and, when so adsorbed, modify many properties of the antibody and qualify its *in vivo* effectiveness. Finally, through a thorough survey of the basic qualities of antibodies, Dr. Horsfall approached the problem of the treatment of human lobar pneumonia and has been instrumental in demonstrating the therapeutic value of anti-pneumococcal rabbit serum.

In his work Dr. Horsfall has exhibited imagination, originality, mental acuity and technical versatility and, because of this fact, the committee believes that this year's selection maintains the high standard set last year—a standard that will inevitably result in the advancement of knowledge in the fields of bacteriology and immunology and be a source of gratification to the donor.

THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY

The Federation of American Societies for Experimental Biology will meet in Baltimore, Md., on March 30 and 31 and April 1 and 2. The Lord Baltimore Hotel will serve as headquarters.

All scientific sessions including motion picture and static demonstrations, except the Federation Joint Session, will be held in the Fifth Regiment Armory. The Federation Joint Session will be held in the Lord Baltimore Hotel.

The scientific sessions will begin on Thursday morning, March 31. Programs will be mailed to members. Wednesday is thus available for visits to points of interest and for other meetings, *i.e.*, of the councils and of the American Institute of Nutrition. No person will be admitted to any of the scientific sessions or demonstrations who can not show the official registration card.

On Thursday evening at nine o'clock the local committee will provide an informal smoker. The annual dinner will be held on Friday evening at seven o'clock.

The new plan for demonstrations and motion pictures will be in effect. According to this plan provision will be made in the Armory for:

a. The continuous showing of static demonstrations during the scientific sessions. Explanation of such demonstrations may be given on multigraphed sheets distributed at the place of demonstration or verbally according to a time schedule posted at the demonstration. Demonstrators will be required to supply this information, but the demonstrations will be identified on the program.

b. Motion picture demonstrations, also identified on the program, will be shown by an operator in a projection room at the Armory several times during the sessions according to a schedule to be announced. Special periods will be provided each day when the operator will repeat showings on request. Demonstrators should provide multigraphed sheets in explanation if needed and if they can not be present to give verbal explanations.

Only 16 mm. films will be shown. No provision will be made for sound projection or for the showing of films which require a licensed operator or which do not conform to the usual underwriters' conditions for home exhibitions.

Those proposing to show static demonstrations or motion pictures as above should communicate with Dr. Chandler M. Brooks (motion pictures), the Johns Hopkins Medical School, or with Dr. D. C. Smith (static demonstrations), department of physiology, University of Maryland Medical School, before February 15, giving titles and brief descriptions.

With the consent and approval of Dr. Philip Bard, chairman of the local committee, provision may be made for laboratory demonstrations requiring special material or apparatus. Dr. Bard should be consulted before February 15.

THE THIRD INTERNATIONAL NEUROLOGICAL CONGRESS

THE Third International Neurological Congress will be held during the last week of August, 1939, in Copenhagen, under the presidency of Professor Viggo Christiansen with Dr. Knud H. Krabbe, Copenhagen, as secretary-general. Dr. H. A. Riley, New York, has been designated a vice-president for the United States; Dr. Gordon Holmes, London; Dr. B. Sachs, New York; Sir Charles Sherrington, Oxford, have been elected honorary presidents. Among the honorary members are: Professor Harvey Cushing, United States; Professor H. Marcus, Sweden; Professor M. Nonne, Germany, and Professor K. Schaffer, Hungary.

Three symposia have been agreed upon for special presentation.

1. Autonomic Nervous System, in charge of Professors von Bogaert and Pette;

2. Heredo-familial Disease, in charge of Professor Guillain, and

3. Avitaminoses, with Especial Reference to the Peripheral Nervous System, in charge of Professor Monrad-Krohn.

RECENT DEATHS AND MEMORIALS

DR. HENRY HERBERT DONALDSON, member of the Wistar Institute of Anatomy, Philadelphia, and professor of neurology at the University of Pennsylvania, died on January 24 in his eightieth year.

DR. JOHN KUNKEL SMALL, director of research and curator of the New York Botanical Garden, died on January 20 at the age of sixty-eight years.

PROFESSOR WILLIAM HENRY PICKERING, director of the astronomical observatory established by Harvard University at Mandeville, Jamaica, died on January 16 at the age of seventy-nine years.

ERNEST EDWARD AUSTEN, from 1927 to 1932 keeper of the department of entomology of the British Museum, an authority on the tsetse fly and tropical diseases, died on January 16. He was seventy years old.

DR. OTTO WARBURG, the botanist, an authority on tropical plants, at one time lecturer at the University of Berlin and professor in the Berlin Oriental Seminary, later president of the World Zionist Organization, died on January 10 at the age of seventy-nine years.

THE centennial of the first public demonstration of the telegraph invented by Samuel F. B. Morse was observed on January 23 in the auditorium of the Washington Square College of New York University. A dramatization of the life of Dr. Morse, professor at the university at the time he invented the telegraph, was broadcast over the WJZ network and the first public demonstration of the instrument was reenacted. Dr. John H. Finley, director of the Hall of Fame, was one of the principal speakers.

ACCORDING to the London *Times* a bronze plaque in memory of William Henry Hudson, the naturalist, known for his work in Argentina, will be placed on the house in which he died on August 18, 1922. The plaque was designed by Señor Luis Perlotti, the Argentine sculptor.

A MONUMENT has been erected in Rio de Janeiro to the memory of Professor Miguel Conto, who was for twenty years president of the National Academy of Medicine.

SCIENTIFIC NOTES AND NEWS

THE gold medal of the Royal Astronomical Society, London, was awarded on January 14 to Dr. William H. Wright, director of the Lick Observatory of the University of California, in recognition of his studies on the spectra of gaseous nebulae and novae, and for his work in the photography of planets.

The Society of Chemical Industry, London, has awarded the Messel Medal for 1938 to Dr. Leo Hendrik Baekeland, president and founder of the Bakelite Corporation and honorary professor of chemical engineering at Columbia University. This medal is given every two years "to the individual who has secured meritorious distinction in the science or literature of chemistry, or in the chemical industry." The only other American who has received the medal is Dr. Robert A. Millikan, of the California Institute of Technology. It will be presented to Dr. Baekeland at the annual meeting of the Society of Chemical Industry in Ottawa on June 21.

Dr. Arno B. Luckhardt, professor of physiology at the University of Chicago, received the dental fraternity Alpha Omega achievement medal at the annual convention in Chicago. This medal is awarded annually to "an outstanding scientist for meritorious services to dentistry or allied arts." The recipient of this award in 1936 was Dr. LeRoy M. S. Miner, dean of the dental school of Harvard University and formerly president of the American Dental Association.

Among the degrees conferred at the installation of Dr. Rufus C. Harris as president of Tulane University were the doctorate of laws on Dr. Alexander G. Ruthven, president of the University of Michigan; on James M. Robert, dean of the College of Engineering at Tulane University, and the doctorate of engineering on Dr. William E. Wickenden, president of the Case School of Applied Science. The doctorate of humane letters was conferred on Dr. Walter Smith Leathers, dean of the School of Medicine of Vanderbilt University, and on Dr. Alphonse Mary Schwitalla, S.J., dean of the School of Medicine, St. Louis University.

The dedication of the first unit of a $9,000,000 pulp mill as part of exercises marking "Florida Industries Day" was made on January 15. Honor was paid to Dr. Charles H. Herty, by whose research in a small laboratory in Savannah the processes of manufacture were discovered. A bronze plaque dedicating the plant to him was unveiled by Walter P. Paepcke, president of the Container Corporation of America, for which the mill was built. Besides Dr. Herty, the speakers included Governor Fred P. Cone, Senator Claude Pepper and Daniel C. Roper, Secretary of Commerce. Dr. Herty was the guest of honor in the evening at a dinner in Jacksonville, given by Governor Cone, in which about a hundred industrialists, financiers and federal and state officials participated.

The Council of the Geological Society, London, has made the following awards: The Wollaston Medal to Professor Maurice Lugeon, of the University of Lausanne, in recognition of the value of his researches on the mineral structure of the earth, particularly in respect of the geological structure of the Alps and of mountain building. The Murchison Medal to Dr. Henry Howe Bemrose, in recognition of his researches upon the igneous rocks of the Lower Carboniferous of Derbyshire and also upon the Pleistocene fauna of the same area. The Lyell Medal to Dr. John Pringle, for his services to paleontological science and particularly in recognition of his work in connection with the Geological Survey and Museum.

Dr. Niels Bohr, professor of physics in the University of Copenhagen, has been elected a correspondent in the section of general physics of the Academy of Sciences, Paris, and Dr. Georges Denigès, formerly professor of biological chemistry in the University of Bordeaux, has been elected a correspondent in the section of chemistry.

The French Minister of Education, according to the *Journal* of the American Medical Association, has conferred the title of honorary professor on three members of the faculty of the Paris Medical School: M. Roussy, who recently was elected rector of the University of Paris; M. Brindeau, obstetrician, and M. Sergent, phthisiologist. The last two have reached the age limit.

Dr. Philip E. Smith, professor of anatomy at the College of Physicians and Surgeons of Columbia University, has been created a Knight of the French Legion of Honor.

The annual meeting of the Franklin Institute was held on January 19, when the following officers were elected: *President,* Philip C. Staples; *Vice-presidents,* Walton Forstall, W. Chattin Wetherill and S. S. Fels. Dr. Harold C. Urey, professor of chemistry, Columbia University, New York City, spoke on "Concentration of Isotopes by Chemical Means." It was announced that the statue of Benjamin Franklin, which will be erected in Franklin Hall, will be unveiled by President Roosevelt during the dedicatory exercises, which will be held on May 19, 20 and 21.

The Society of Economic Geologists has elected for the year 1939: *President-elect,* Arthur C. Veatch, New York City, and *Vice-president-elect,* Dr. Elwood S. Moore, of the University of Toronto. Dr. Donald H. McLaughlin, of Harvard University, was installed as president at the Washington meeting.

Officers of the Pathological Society of Philadelphia for 1938 are: Dr. Baxter L. Crawford, pathologist to the Jefferson Hospital, *president;* Dr. Jefferson H. Clark, director of the Laboratories of the Philadelphia General Hospital, *vice-president,* and Dr. Herbert L. Ratcliffe, department of pathology, University of Pennsylvania, *secretary-treasurer.*

AT the December elections of the Academy of Medicine of Washington, D. C., the following officers were chosen: *President,* Dr. Carl Voegtlin; *Vice-president,* Dr. Sterling Ruffin; *Treasurer,* Dr. Daniel L. Borden; *Secretary,* Dr. Errett C. Albritton; *Directors,* Drs. Prentiss Willson, Merle A. Tuve, Matthew W. Perry, Earl B. McKinley and Lyman J. Briggs. At its winter meeting on January 29 the academy will have as guest speaker Dr. Frederick Parker Gay, professor of bacteriology, College of Physicians and Surgeons, Columbia University, who will speak on "Medical Logic."

AT West Virginia University, Dr. F. D. Fromme has resigned as dean of the College of Agriculture and director of the Agricultural Experiment Station and Extension Division, effective on February 1, to accept appointment as principal experiment station administrator in the Office of Experiment Stations, U. S. Department of Agriculture. Dr. C. R. Orton, professor of plant pathology, succeeds him as dean and director of the station, and J. O. Knapp becomes acting director of extension.

DR. J. C. WARNER, associate professor of metallurgy at the Carnegie Institute of Technology, Pittsburgh, has been appointed professor of chemistry and head of the department of chemistry, the appointment to become effective on July 1. Dr. Warner will succeed Dr. J. H. James, who will retire at the end of this session. Dr. James is on leave of absence this year, and Dr. Thomas R. Alexander is acting head of the department during the interim.

DR. EDWARD WILLIAM WALLACE, recently of the staff of the National Institute of Health, Washington, D. C., has been appointed assistant professor in the department of pharmacology at the University of Cincinnati College of Medicine.

AT the Harvard College Observatory Dr. Annie Jump Cannon has been appointed William Cranch Bond astronomer and curator of astronomical photographs; Dr. Cecilia Payne Gaposchkin has been appointed Phillips astronomer. They have been members of the observatory since 1897 and 1927, respectively.

DR. IVOR GRIFFITH has been appointed dean of pharmacy of the Philadelphia College of Pharmacy and Science to succeed the late Dr. Charles H. LaWall. Dr. Griffith, who prior to this election held the position of assistant dean of pharmacy and professor of theory and practice of pharmacy of the college, is editor of the *American Journal of Pharmacy.*

DR. C. H. MAHONEY, research associate in horticulture at the Michigan State College, has been appointed professor of olericulture at the University of Maryland. He will be in direct charge of teaching, extension and research of the vegetable work at College Park.

DR. A. T. BAZIN, professor of surgery at McGill University, has been appointed dean of the department of surgery.

ARTHUR B. RECKNAGEL, professor of forestry at Cornell University, left on January 11 to assume his work as exchange professor of forestry at the University of British Columbia, Vancouver. He will teach forest management and forest products and marketing and will study forest practice in the Douglas fir region.

DR. LEONARD P. SCHULTZ, assistant curator in the Division of Fishes of the U. S. National Museum, has been appointed curator.

DR. HANS STILLE, professor of paleontology at Berlin, has been elected secretary of the Prussian Academy of Sciences.

DR. FRITZ VON WETTSTEIN, director of the Kaiser Wilhelm Institut für Biologie, Berlin-Dahlem, is a guest investigator at the Department of Genetics of the Carnegie Institution of Washington at Cold Spring Harbor for the months of January and February. He plans to visit institutions on the Pacific Coast during March and then to return to Germany by way of the Panama Canal. Dr. Åke Gustafsson, docent at the University of Lund, is spending the year at the Department of Genetics on an international fellowship of the Rockefeller Foundation.

The British Medical Journal reports that the League of Nations has sent a medical mission to the Far East to take measures to prevent or control the spread of epidemics. The mission is headed by Inspector-General Lasnet, of the Academy of Medicine, Paris, Dr. Hermann Mooser, representing Germany, and Dr. Robert Cecil Robertson, representing Great Britain. The mission will first visit Hong Kong and continue its work in South China.

DR. F. R. MOULTON, permanent secretary of the American Association for the Advancement of Science, gave an address before the Washington Academy of Sciences on January 20. His subject was "Celestial Sciences."

PROFESSOR W. C. ALLEE, of the department of zoology at the University of Chicago, will give six lectures on the Norman Wait Harris Foundation of the Northwestern University on "Group Action among Animals and its Social Implications."

THE fourth lecture in the Smith-Reed-Russell series for this year at the School of Medicine of the George Washington University was held on January 11, when

Dr. Edwards A. Park, head of the department of pediatrics of the Johns Hopkins Hospital, spoke on "Various Types of Bone Diseases in Children."

THE seventh International Congress of Genetics will meet in Edinburgh in 1939, probably from August 23 to 30. Professor F. A. E. Crew, of the Institute of Animal Genetics, University of Edinburgh, has been appointed general secretary to the congress.

THE Eta Chapter of California of Phi Beta Kappa was installed at the University of California at Los Angeles on January 14. Dr. Robert Andrews Millikan, chairman of the Executive Council of the California Institute of Technology, acted as installing officer, and Dr. Charles B. Lipman, dean of the Graduate Division of the University of California, delivered an address on "A Proposed New Rôle for Phi Beta Kappa in American Education." The faculty officers of the chapter are: *President,* Dr. Alexander Green Fite; *First Vice-president,* Dr. Bennet M. Allen; *Second Vice-president,* Dr. Margaret Sprague Carhart; *Third Vice-president,* Dr. Frederick C. Leonard; *Secretary,* Dr. Paul H. Daus; *Treasurer,* Dr. Herbert Benno Hoffleit.

TRENDS in medical education and medical practice will be discussed by medical men at the symposium on higher education in the South which has been arranged as a feature of the installation ceremonies of Chancellor Oliver C. Carmichael, of Vanderbilt University, on February 3, 4 and 5. Among the speakers are: Dr. Irvin Abell, professor of surgery at the University of Louisville, president-elect of the American Medical Association, who will discuss "Significant Trends in Medical Practice"; Dr. Thomas Parran, Surgeon General of the United States Public Health Service, will speak on "A Forward Look at National Health"; Dr. Wilburt C. Davison, professor of pediatrics and dean of the School of Medicine of Duke University, will speak on "A Survey of Medical Education in the South"; Dr. William D. Cutter, secretary of the Council of Medical Education and Hospitals of the American Medical Association, will deliver an address on "Trends in Pre-Medical and Medical Education."

THE Midwestern Psychological Association will hold its annual meeting at the University of Wisconsin, on April 22 and 23, under the presidency of Dr. Arthur G. Bills, of the University of Cincinnati. The title of his presidential address will be "Changing Views of Psychology as Science." A special feature of the meeting will be the celebration of the fiftieth anniversary of the founding of the psychological laboratory at the University of Wisconsin by Joseph Jastrow.

IN December, 1937, the Duke University Medical Society was organized to facilitate the presentation of current medical problems before the students, the staff and other interested persons in the university and professional community. Meetings are held monthly during the academic year, and the programs usually consist of short case presentations and discussions followed by a description of some staff or student research project. Occasionally, guest speakers from other institutions are invited to participate in the programs. The first meeting was held on December 7, at which Dr. Wiley D. Forbus gave the introductory talk, and Dr. D. T. Smith spoke on "Experimental Canine Blacktongue." At the second meeting, held on January 11, Dr. Ralph W. G. Wyckoff, of the Rockefeller Institute, Princeton, N. J., was the guest speaker, his subject being "The Ultra-centrifugal Study of Macromolecules."

IN the will of Arthur S. Lea, formerly a member of the publishing firm of Lea and Febiger, Philadelphia, who died two weeks ago at the age of seventy-nine years, large bequests are made to educational, religious and charitable institutions. Besides receiving outright bequests, Harvard University, from which Mr. Lea was graduated, and the University of Pennsylvania each will have 40 per cent. of the residuary estate, and the Children's Hospital of Philadelphia 20 per cent. No estimate of the probable amount was available. Princeton University will receive $150,000 in trust for the establishment of a professorship in history, preferably medieval. A gift of $52,500 to the University of Pennsylvania provides for printing and publishing the works of the testator's father, Henry Charles Lea, the historian. The university museum also receives $10,000 for general use. Other bequests include $50,000 to the following institutions: the Jefferson Medical College for research in streptococcus infection; the Pennsylvania Hospital, the College of Physicians of Philadelphia, the Drexel Institute, the Southeastern Pennsylvania chapter of the Red Cross, the National American Red Cross, the Academy of Natural Sciences of Philadelphia, the Franklin Institute, the Philadelphia Zoological Gardens and the Library Company of Philadelphia.

THE new building for the School of Medicine of Indiana University, erected at a cost of $475,000, was recently dedicated. It houses the departments of anatomy, hygiene and physiology and contains the combined libraries of the three departments. Speakers at the dedication included M. Clifford Townsend, governor of Indiana; United States Senator Sherman Minton, and Dr. Fred C. Zapffe, secretary of the Association of American Medical Colleges.

ACCORDING to an Associated Press dispatch from

Berne the Swiss Government has inaugurated a weather bureau station on the Jungfrau, which rises 13,672 feet above sea level. Dr. Philippe Etter, Minister of the Interior, was the principal speaker at the ceremonies. The project was financed largely by private scientific and Alpine organizations.

DISCUSSION

THE CLIMATIC HYPOTHESIS IN GEOGRAPHY

A survey of geographic literature shows coherent development of the data of landscape in terms of climate. Caution, however, is desirable, because of the uncertainty of the meteorological material upon which "climate" as such has been based. Unless stability of meteorological conditions over periods long enough to make averages meaningful can be demonstrated, the whole framework of climate based upon statistical averages will have to be abandoned. The researches of Sears and of the other pollen-analysts have shown rather profound changes in climatic conditions to have been taking place during the past three to five hundred years.[1] The analyses of Douglas, working on tree rings in connection with archeological investigations in the southwestern part of the United States, have shown that throughout the reconstructable period of the ancient pueblos climatic irregularity has characterized the yearly progress of atmospheric conditions.[2] For longer periods, Antevs in the United States and DeGeer in Sweden by the study of varves have demonstrated the fluctuations of climate in immediately post-Pleistocene times and for considerable periods since.[3] C. E. P. Brooks has collected much evidence of the history of climate.[4] The view which must emerge from the consideration of this evidence is that climate is in a state of continuous fluctuation and change. It is not static; it varies from year to year, from decade to decade, and from millennium to millennium, though perhaps with measurable cycles and epicycles upon possible longer cycles from glaciation to glaciation.

Recently Koeppen and others have constructed climatic systems on the basis of averages of meteorological data.[5] These systems are utilized more or less widely in the "regional" organization of geographical data and in conjunction with the more detailed study of small "regions," perhaps more in the United States than in Europe.[6] Geographers have been able to organize the data of landscape more successfully in terms of climate than in any other way. Alexander von Humboldt foreshadowed the way in which geography was to develop when he described the domain of plant geography in the Kosmos and when he invented the isotherm. The publication of "The Origin of Species" started a combing of the world for evidence of natural selection, of which search zoogeography was a by-product, though its first phases had been illuminated by Buffon. Wallace's "Geographical Distribution of Animals" rests philosophically on a foundation of climatic difference. Davis, in his physiographic work, found it necessary to introduce modifications of his system in the case of arid regions, and had his observational experience been wider he would perhaps have worked out systems for the humid tropics and for the polar regions of frozen soil.

If climate has history, if it consists of continuously varying combinations of the meteorological elements, as was presented above, it would seem impossible to measure it in terms of averages; its data are too elusive. As a consequence it will be necessary to abandon the various schemes which have been proposed and to proceed with the investigation of climate along other lines. Furthermore, the distribution of vegetation, to take but one element in the "geographic complex resting on climate," is not determined by the distribution of average meteorological conditions (whether measurable or existing, or not), but rather, probably, by extremes of temperature or of rainfall or of some other factor occurring in certain unascertainable combinations during certain, perhaps ascertainable, critical periods in the lives of the individuals and species making up the vegetation of the world.

If the regional organization of geographic material is impossible in the tradition of von Humboldt, Wallace and Koeppen, if the serviceability of climatic maps expressed in terms of isotherms, isohyets and isobars is open to question because of the defect of averages, what remains for the climatic hypothesis which has proved so useful in geography? It is probable that landscape should be considered as a system of variables—climate varies in time, as we have seen; the geologic "base" of landscape varies also, diastrophically. Landscape as a variable has been summed up diagramatically by Sauer,[7] and it is the complex pattern there expressed to which geographers should devote themselves. If climate, though not alone, work through time to produce "forms" of the "natural landscape" and if climate be variable, it becomes necessary to study somehow the ways in which the other variables

[1] *American Anthropologist*, 34: 610–622, 1932.

[2] Carnegie Inst. of Wash., Pub. No. 289, 1919–26, 2 vols.

[3] Ymer, 45, 1925; Carnegie Inst. of Wash., Pub. No. 352, 1925.

[4] "Climate through the Ages," London, 1926; "The Evolution of Climate," London, 1925.

[5] "Grundriss der Klimakunde," etc., Koeppen-Geiger, "Handbuch der Klimatologie," *et al.*

[6] *Univ. Calif. Pub. in Geog.*, 2 p. 272; *Papers*, Mich. Acad., 1932, p. 248; *Annals*, A.A.G., 26, 1936, p. 159. These papers are cited as samples, and are not necessarily bad in themselves otherwise.

[7] *Univ. Calif. Publications in Geog.*, 2, p. 41.

behave in reference to this one. In this way, climate may be approached through tangible evidences of its past. Pollen analyses, tree ring analyses, soil studies, studies in plant and animal ecology and studies in archeology (e.g., the work of Douglas) may be organized in a complex whole, the study of which in the field and in the laboratory may provide a body of data so coherent that geography will not have to depend on an untenable foundation of statistical climatic regions, the data of which are so complex as to defy reduction to averages.

STANLEY D. DODGE
THE UNIVERSITY OF MICHIGAN

FERTILITY AND INTELLIGENCE OF COLLEGE MEN

VERY little based on direct evidence is known concerning fertility differentials with respect to intelligence. Such inferences as have been attempted are based primarily upon correlations of the intelligence scores of children with the number of their siblings—*i.e.,* with the fertility of their *parents;* but it is plainly the correlation of intelligence with the individual's own fertility which is of eugenic interest.

Opportunity is arising to collect a limited amount of direct evidence from that part of the population which was tested in colleges with the early group tests. Such data are obviously imperfect; they are incomplete, since students tested as freshmen in 1918 are now about 37 years old and may produce children for another dozen years; they are affected by selective factors, since it is likely that certain types of alumni are disproportionately represented in the available records on fertility; and they are restricted to a single social class. Nevertheless, it seems desirable to learn what we can about this important social phenomenon. Exploratory analyses have therefore been made on the records of the Brown class of 1924 (tested in September, 1920, with the Brown University Psychological Examination).

One hundred sixty-eight graduates for whom there are records beyond the twenty-eighth birthday may be divided at their median into a high and a low scoring group. Chi-square comparison of the distributions of ages at last (reproductively significant) record for these two groups indicates that they may be regarded as samples of the same population ($P = .7$), and that therefore neither will be greatly penalized in this respect by a direct comparison. Such a comparison gives .84 children per man for the high group and .61 for the low, a ratio of about 1.4; these figures, of course, are minima.

A more satisfactory evaluation may be made by considering only those men whose last reports fell subsequent to a given birthday; these may be divided at the median as before, and for each of the two subgroups the number of children per man born before the specified birthday may be computed. Such figures are still minima, but the "temporal opportunity" to have children has been accurately equated as between the two subgroups compared at each birthday. Comparisons of this sort made for the birthdays for which significant data are available (29–34) yield High/Low ratios of 1.5 to 2.1, derived from per-man reproductivities of .42 to 1.00 for the high group and .20 to .54 for the low. The N's run from 139 to 49 for the undivided groups (*i.e.,* half as large for the high and low groups).

Various measures of reproductive efficiency, however, show insignificant differences between high and low scorers. Thus the 52 high-scoring married men have produced .19 children per man per married year and the 54 low-scoring ones .20. The intervals between marriage and first birth are very close to two years for those subgroups (35 and 37 in number) of high and low scorers who have had children. The numbers of children born in a given age period per man married at the beginning of the same period are even slightly higher for the lower groups (*e.g.,* 1.17 and 1.25 for children born between 29 and 34 per man married by 29). Finally, the numbers of children born after a given birthday to high and low groups are not greatly different; the high group has a slight advantage for the earlier birthdays and the low for the later ones.

Further analysis shows that the effective differential is in fact entirely in the marriage rate and not in the reproductive efficiency. Thus for the 139 men last known at 29 or above (who are typical), we have the following cumulative percentages:

	Married by							Unmarried by
	23	24	25	26	27	28	29	29
High	9	15	26	31	48	57	60	40
Low	4	10	12	22	27	37	48	52

By means of an arbitrary set of assumptions we may guess at the final reproductivities of the groups. For this purpose we assume that a married man for whom three years have elapsed since his marriage or the birth of his last child, or an unmarried man over 32, will have no more children, while all others will have one more each. The application of these assumptions equally to the two groups raises the per-man reproductivity of the high scorers from .84 to 1.55 and that for the low scorers from .61 to 1.26, but depresses the High/Low ratio from 1.39 to 1.23. Taking into account that the number of persons to be reproduced is slightly more than double the number of subjects, and that even in this privileged group some children

do not survive to reproduce, it is clear that the assumptions made would have to be deficient to an improbable degree to make survival probable, since for such a result the reproductivity figure may be placed at about 2.1 or 2.2. That is, the group as a whole would have to produce, to survive, about 1.5 times as many children after the age of 32 as it has produced before that age, or in all about half as many again as it seems likely to produce on the basis of reasonable assumptions.

Thus the investigation, in spite of imperfect data, has provided us with a fairly unambiguous conclusion: High-scoring college men produce substantially more offspring than low-scoring college men, and they are able to do this solely because they marry earlier and more frequently. One may speculate that they marry earlier because their superior intelligence enables them to establish themselves economically earlier—although it seems remarkable that differences as small as those between high and low scoring college men, and in a trait with such limited correlations with practical abilities, should be as effective as this. But in any case it makes little difference, for less than 40 per cent. of even the higher group can expect to be fully represented in the next generation.

RAYMOND R. WILLOUGHBY
BROWN UNIVERSITY

THE NON-TOXICITY OF GOSSYPOL TO CERTAIN INSECTS

THE 6,000,000 to 8,000,000 tons of cottonseed produced annually in this country represent a potential source of 40,000 to 80,000 tons of gossypol. Anticipating the ultimate availability of this interesting compound as an industrial raw material, various experimental approaches to determine its possible uses have been made. The chemical and physical properties of gossypol have recently been reviewed by Adams and co-workers.[1] Its anti-oxygenic action, as demonstrated in fats and oils,[2,3] indicated several possibilities which are being investigated. Its toxicity to mammals and birds[4] suggested that gossypol might be useful as an insecticide. Some negative results are published here for the information of those who might also have been interested in this possibility.

The standard laboratory technique for assaying insecticides was employed. Wooly aphids were sprayed with emulsions containing gossypol and dianiline gossypol in concentrations of 1 to 500. The compounds were dissolved in a small amount of dioxane, then diluted with an aqueous solution of a potassium soap (1:2000). At the end of 24 hours the aphids were as active as were the negative controls. Much lower concentrations of known insecticidal compounds showed 100 per cent. mortality.

Lima bean leaves were sprayed with emulsions containing gossypol and dianiline gossypol (1 to 1000), allowed to dry, and offered separately to groups of Mexican bean beetles. After 24 hours, the leaves were as skeletonized as those which had been sprayed only with the wetting agent, and the beetles were unharmed. Leaves which had been sprayed with dilute solutions of rotenone were unattacked.

These results indicate that, at least to the insects tried, gossypol and dianiline gossypol are ineffective either as contact or stomach poisons.[5]

E. P. BREAKEY
H. S. OLCOTT
Cotton Research Foundation
MELLON INSTITUTE OF INDUSTRIAL RESEARCH

[1] K. N. Campbell, R. C. Morris and R. Adams, *Jour. Am. Chem. Soc.*, 59: 1723, 1937.
[2] H. A. Mattill, *Jour. Biol. Chem.*, 90: 141, 1931.
[3] H. D. Royce and F. A. Lindsay, Jr., *Ind. Eng. Chem.*, 25: 1047, 1933.
[4] W. A. Withers and F. E. Carruth, *Jour. Agr. Res.*, 14: 435, 1918, and many others.
[5] After these experiments had been completed, we learned from Dr. E. P. Clark, of the Division of Insecticide Investigation, U. S. Dept. of Agriculture, Washington, that he had also obtained negative results in assays of gossypol for insecticidal activity. Moreover, one of us (H. S. O.) has shown that neither gossypol nor any one of several simple derivatives possesses germicidal activity toward *B. typhosis*.

THE COMMON BLUE CRAB IN FRESH WATERS

HAY[1] has given several records of the occurrence of the blue crab, *Callinectes sapidus* Rathbun, in inland coastal waters. Nevertheless, there seems to be a rather general opinion that this crab does not migrate completely beyond the influence of the sea. Brues,[2] in recording the related *Callinectes ornatus* Ordway from fresh water in Cuba, states that he has found no record of any *Callinectes* away from salt water.

On August 4, 1937, a male blue crab was caught in a sunken bucket near the floating dock of the Simmesport Fish Company in the Atchafalaya River at Simmesport, La. It was not adult, measuring 4.5 inches across the carapace. Simmesport, near the origin of the Atchafalaya, is over 160 miles from the Gulf of Mexico as the river runs. Commercial fishermen commonly take crabs there during the summer, and this is an indubitable record of the crustacean in fresh water, beyond the influence of the sea.

Rathbun[3] records this crab from the Hudson River at West Point; the Coloosahatchie River, Fla.; Rio Cobre, Jamaica, and gives other records which might

[1] *Rep. Bur. Fish.*, 1904: 397–413, 1905.
[2] *Amer. Nat.*, 61: 566–569, 1927.
[3] *U. S. Nat. Mus. Bull.*, 152: 1–609, 1930.

be considered fresh water from Nicaragua and Brazil. Brues[2] cited some of these records from Rathbun's previous papers.

The blue crab invades pure fresh water and probably does so over its whole range from Nova Scotia to Uruguay.

GORDON GUNTER
MATAGORDA BAY OYSTER FARMS, INC.,
MATAGORDA, TEXAS

SOCIETIES AND MEETINGS

THE MINERALOGICAL SOCIETY OF AMERICA

THE eighteenth annual meeting of the Mineralogical Society of America was held at the Hotel Washington, Washington, D. C., from December 28 to 30, 1937, in conjunction with the Geological Society of America. Over one hundred and fifty members of the society, from all parts of the United States, were present.

The following officers for the coming year, 1938, were elected: *President,* Ellis Thomson, of the University of Toronto; *Vice-president,* Kenneth K. Landes, of the University of Kansas; *Secretary,* Paul F. Kerr, of Columbia University; *Treasurer,* Waldemar T. Schaller, of the United States Geological Survey; *Editor,* Walter F. Hunt, of the University of Michigan. R. C. Emmons, of the University of Wisconsin, was elected councilor for the period 1938–1941.

The following members were elected to fellowship: Henry R. Aldrich, assistant secretary of the Geological Society of America; Donald M. Fraser, of Lehigh University; William T. Gordon, of Kings College, London; M. S. Krishnan, of the Geological Survey of India; Donald H. McLaughlin, of Harvard University; James A. Noble, of the Homestake Mining Company; Frederick H. Pough, of the American Museum of Natural History; V. Rosicky, of the University Masaryks Brno, Czechoslovakia; Quentin D. Singewald, of the University of Rochester; Benjamin M. Shaub, of Smith College; Lloyd W. Staples, of Oregon State College; Edward H. Watson, of Bryn Mawr College.

The retiring address of the president, Dr. Norman L. Bowen, of the University of Chicago, was delivered before a joint session of the Geological Society of America and the Mineralogical Society of America on Tuesday, December 28. Dr. Bowen's topic was "Mente et Malleo atque Catino." Dr. Bowen stressed the importance of the coordinated three-fold attack on experimental problems in the development of mineralogical science.

Four sessions for the presentation of papers were held. On Tuesday afternoon, December 28, a joint session with the Geological Society of America and the Society of Economic Geologists was held for the presentation of papers on petrography and economic phases of mineralogy, with William S. Bayley, vice-president of the Geological Society of America, as chairman. After the joint session, a regular session for the presentation of papers dealing with new developments in scientific equipment was held. A number of novel optical developments in the application of polarized light to the microscope were offered. On Wednesday afternoon, December 29, papers dealing with new developments in mineralogy were presented. Among other contributions, the new mineral *yeatmanite* from Franklin, New Jersey, was described. On Thursday morning, December 30, a session was held for the presentation of papers on geometrical crystallography, structure of crystals and mineral optics. President Bowen, together with past presidents E. T. Wherry, of the University of Pennsylvania, and A. L. Parsons, of the University of Toronto, presided over the various technical sessions of the society.

On Wednesday, December 29, the annual luncheon of the society took place in the Sun Parlor of the Hotel Washington. During the luncheon, President Bowen introduced Dean Edward H. Kraus, who presented the Roebling Medal to its first recipient, Dr. Charles Palache, of Harvard University. The Roebling Medal is named in honor of the late Colonel Washington A. Roebling and is awarded for "meritorious achievement in mineralogy and allied sciences."

The nineteenth annual meeting of the society will be held from December 28 to 30, 1938, in New York City.

PAUL F. KERR,
Secretary.

THE AMERICAN ORNITHOLOGISTS' UNION

THE fifty-fifth annual meeting of the American Ornithologists' Union was held at the Charleston Museum, South Carolina, from November 15 to 18, 1937. The three days of program sessions included a like number of evening entertainments: Open house at the museum, the annual dinner and a tour of a selected group of colonial homes in Charleston. On the fourth day more than two hundred ornithologists in attendance visited Bull's Island of the U. S. Biological Survey, Cape Romain Refuge.

Officers elected for the new year were as follows: *President,* Dr. Herbert Freidmann, Washington, D. C.; *Vice-presidents,* Dr. J. P. Chapin, New York City, and Dr. J. L. Peters, Cambridge; *Secretary,* Dr. Lawrence E. Hicks, Columbus; *Treasurer,* W. L. McAtee, Washington, D. C.; *Council,* Dr. R. C. Murphy, New York City, Dr. T. S. Palmer, Washington, D. C., Hoyes Lloyd, Ottawa, and Dr. Josselyn Van Tyne, Ann Arbor.

The Brewster Medal Award was made to Dr. Robe

Cushman Murphy for his volumes on "Oceanic Birds of South America." Two fellows, Dr. Ernst Mayr, New York City, and Mrs. M. M. Nice, Chicago, and one corresponding fellow, R. C. Falla, Christchurch, New Zealand, were elected.

In addition to 234 new associate members, six new members were named: W. P. Brodkarb, Ann Arbor; James Moffitt, San Francisco; M. D. Pirnie, Augusta, Mich.; O. S. Pettingill, Jr., Northfield; W. P. Smith, Wells River, Vt.; F. M. Uhler, Washington, D. C.

Delegates to the International Ornithological Congress, 1938, are Alexander Wetmore, J. P. Chapin, J. H. Fleming and J. C. Greenway. The 1938 meeting will be held in Washington, D. C., and the 1939 meeting in California.

LAWRENCE E. HICKS,
Secretary

THE NORTHWEST SCIENTIFIC ASSOCIATION

THE fourteenth annual meeting of the Northwest Scientific Association was held on December 28 and 29 at the Davenport Hotel, Spokane, Wash. The organization's membership is drawn largely from members of the science staffs of the institutions of higher learning in Montana, Idaho, Washington and Oregon, augmented by scientists and engineers in applied fields throughout the Pacific Northwest. Official registration was 148, although visitors and guests swelled the attendance to more than 200 at the section meetings.

The speaker at the opening general session was Dr. E. C. Johnson, dean of the College of Agriculture, State College of Washington, Pullman, who related some of his summer's observations on the collective farms of the U.S.S.R. at the annual dinner. Dr. H. K. Benson, head of the department of chemistry and chemical engineering, University of Washington, Seattle, gave the principal address, speaking on "The Application of Chemistry to Industry." At the joint luncheon with the Associated Engineers of Spokane on the second day, Dr. Benson also spoke, taking as his subject "A Chemurgic Program for the Northwest."

The annual Sigma Xi breakfast was followed by an illustrated lecture on the origin of Crater Lake, entitled, "Mt. Mazama—Explosion *vs.* Collapse," presented by Dr. Warren D. Smith, head of the geology-geography department at the University of Oregon, Eugene.

Aside from the general sessions, special section meetings were held for the following groups: (a) Bacteriology and Public Health, (b) Botany-Zoology, (c) Chemistry-Physics-Mathematics, (d) Education-Psychology, (e) Engineering, (f) Forestry, (g) Geology-Geography, (h) Social Science and (i) Soil Conservation. A total of 89 papers were presented.

Officers elected for 1938 include: Dr. J. H. Ramskill, Montana State University, Missoula (forestry), *president;* Dr. E. F. Gaines, State College of Washington, Pullman (agronomy), *vice-president;* W. B. Merriam, Eastern Washington College of Education, Cheney (geography), *secretary-treasurer,* with Dr. C. C. Todd, Pullman, retiring president, and Dr. E. C. Jahn, University of Idaho, Moscow, *councilors.*

Trustees elected were: E. M. Keyser, Spokane, and Dr. William H. Cone, Moscow, Idaho, for the three-year term, and Thomas Large, Spokane; C. C. Johnson, Pullman, and Gerhard Kempf, Priest River, Idaho, for the one-year term. Dr. O. W. Freeman, Cheney, was elected editor of *Northwest Science,* the official publication of the association.

W. B. MERRIAM,
Secretary

SPECIAL ARTICLES

THE ULTRACENTRIFUGAL CONCENTRATION OF THE IMMUNIZING PRINCIPLE FROM TISSUES DISEASED WITH EQUINE ENCEPHALOMYELITIS[1]

IT has recently been shown that the virus of equine encephalomyelitis (Eastern strain) can be sedimented and separated from accompanying non-infectious tissue elements by quantity ultra-centrifugation; especially active preparations made in this way contained large amounts of a homogeneous heavy substance that may well be the infectious agent.[2] Several years ago it was found[3,4] that injection of non-infectious formalin-treated brains of guinea pigs dying of this disease would protect healthy guinea pigs against later injections of active virus suspensions. We have used the ultracentrifuge to concentrate and purify the immunizing principle from formalin-inactivated diseased tissues.

Our formalinized tissue suspensions were completely inactive as judged by their ability to initiate disease in either mice or guinea pigs; when injected in suffi-

[1] The part of this investigation carried out at Duke University School of Medicine and Duke Hospital was made possible through the interest and aid of the Lederle Laboratories, Pearl River, N. Y. We acknowledge with appreciation the technical aid of Mary Shipp, Department of Anatomy, Duke University School of Medicine.

[2] R. W. G. Wyckoff, *Proc. Soc. Exp. Biol. and Med.*, 36: 771, 1937.

[3] M. S. Shahan and L. T. Giltner, *Jour. Am. Vet. Med. Asn.*, 84: 928, 1934.

[4] P. K. Olitsky and H. R. Cox, *Jour. Exp. Med.*, 63: 745, 1936.

cient amounts they were capable of immunizing guinea pigs. For experiments in concentration such suspensions were cleared of gross material by low-speed centrifugation and then run one and a half hours in a quantity ultracentrifuge[5] using a field of ca 60,000 g. Samples of the supernatant liquids, which were of high protein content, were reserved for tests of immunizing power; the rest was discarded. The large pellets found after ultracentrifugation were resuspended, and their solutions further purified by repetition of the cycle of low-speed centrifugation and ultracentrifugation.

Ultracentrifugal analytical examination of the final solutions has shown the sharply sedimenting boundaries of a molecular species with a sedimentation constant of the order of 60×10^{-13} cm sec.$^{-1}$ dynes^{-1}. In no instance was there to be seen any trace of the more rapidly sedimenting material that may be the infectious substance.[2]

The immunizing capacities of the supernatant fluids and of the final solutions have been tested by subcutaneous injection into 400-gram guinea pigs of two equal doses at an interval of one week, and by intracerebral injection of 100 to 500 minimal lethal doses of active virus two weeks after the second immunizing injection. Complete immunity has been conferred by small amounts of the final product, whereas the supernatant fluids have been devoid of immunizing capacity. In one experiment, for example, there was survival of three out of four guinea pigs receiving solutions containing a total of 0.2 mg. of protein. Two of these animals gave no reaction to 200 lethal doses of virus, the third became ill but promptly recovered. In another experiment in which the protein content of the protective injections was 0.25 mg each, three out of four animals survived 500 minimal lethal doses of active virus without rise in temperature or clinical manifestations of the disease. All guinea pigs injected with the corresponding supernatant fluids died in less than 72 hours. The results of other experiments have been similar. This work is being continued.

J. W. Beard
Harold Finkelstein
W. C. Sealy

Department of Surgery,
Duke University School of Medicine

Ralph W. G. Wyckoff

Rockefeller Institute for Medical
Research, Princeton, N. J.

VITAMIN B_1 REQUIREMENTS OF DIFFERENT STRAINS OF WHITE RATS

From the time the International Standard of vitamin B_1 was first adopted and made available, the conversion of Sherman Chase units of B_1 to International units has been a point of difference between laboratories. Conversion factors varying from two up to four or five have been reported. These variations have been tentatively explained on the basis of strain differences with the suspicion frequently that diet and technique might contribute largely to the results.

We have had the opportunity in the past two years of using three different strains of white rats in vitamin B_1 work, and have fed a number of groups on different levels of synthetic crystalline B_1. The results obtained with the three strains on a 2 gamma B_1 per day level, with two strains on a 4 gamma level, and one strain on an 8 gamma level, illustrate differences in three strains in their growth response to the feeding of vitamin B_1:

Strain	2 gamma fed daily Ave. gain in 5 weeks Gms.		4 gamma fed daily Ave. gain in 5 weeks Gms.		8 gamma fed daily Ave. gain in 5 weeks Gms.	
A ...	33.3	± 1.9	52.8	± 2.3	....	
B ...	14	± 1.64	27.6	± 1.04	52.9	± 2.8
C ...	29.8	± 3.38	....		....	

These strain differences are inherent, as the young of the breeding stock of these three strains fed on the same stock ration give the characteristic response to B_1 supplements indicated in the table.

Variations in the factor for the conversion of Sherman Chase units to International units can be adequately explained by strain differences in the requirements of the test animals. It is obvious that each laboratory must determine its conversion factor for its particular strain of animals. It is suggested that the development of strains having uniform B_1 requirements is necessary if accurate results are to be obtained.

R. F. Light
L. J. Cracas

The Fleischmann Laboratories,
New York, N. Y.

THE EFFECT OF HUMIDITY ON THE DEVELOPMENTAL RATE OF CHICK EMBRYOS INCUBATED UNDER INCREASED ATMOSPHERIC PRESSURE

Using a slightly modified pressure incubator, originally described in Science,[1] a study was made of the effect of humidity on developmental rate of chick embryos during the first eleven days of incubation. Previous studies[2] had shown an acceleration of growth

[5] R. W. G. Wyckoff and J. B. Lagsdin, *Rev. Sci. Instruments*, 8: 74, 427, 1937.

[1] Science, 80: 99–100, 1934.
[2] *Jour. Elisha Mitchell Sci. Soc.*, 52: 269–273, 1936.

under pressure as compared to controls, the temperature and relative humidity being constant and comparable in both pressure and control incubators. It was noticed, however, that the control eggs lost water more rapidly than the experimental, and it was therefore suggested that the retention of water might be responsible in part for the accelerated growth. Other workers had already observed that increased humidity, within rather wide limits, increased the growth rates of chick embryos at normal pressures.

To determine whether or not the decreased water loss, which in turn is dependent upon the humidity of the surrounding atmosphere, was in part responsible for the increased growth rate of the chick embryos, the humidity in the pressure incubator was lowered until the water loss of the experimental eggs was comparable to that of the controls. When these adjustments had been made, 40 eggs were placed in the pressure incubator and maintained at a pressure of 25 to 30 pounds; 33 control eggs, matched by weight with the experimentals, were incubated at normal pressure. Both lots of eggs were incubated at 100° F.

After eleven days, the embryos were removed, stripped of their membranes and weighed with the following results.

TABLE 1

	Control	Experimental
Average original weight of eggs ..	58.9 gr.	59.7 gr.
Average water loss	1.8 "	2.0 "
Average weight of embryos	3.69 "	6.07 "

Per cent. increase in weight of experimental embryos over the controls was slightly more than 60 per cent.

When compared to the 42 per cent. increase secured in the best of the earlier experiments where the relative humidity in control and experimental incubators was kept the same, it would appear that the retention of water prevents the maximum effect of the pressure, and pressure may now be definitely considered as responsible for the accelerated growth.

BERT CUNNINGHAM

DUKE UNIVERSITY

CRYSTALLIZATION OF TOBACCO-MOSAIC VIRUS PROTEIN

METHODS for the crystallization of tobacco-mosaic virus protein specify a preliminary precipitation of certain proteins in amorphous form previous to obtaining the crystalline or liquid crystalline protein. Bawden and Pirie[1] reported that heating the crude infectious sap to 70 C. before clarifying it by centrifugation saved considerable time in that the virus protein could be isolated by direct precipitation with acid or ammonium sulfate, thus eliminating preliminary precipitation with alcohol. It has been found and herein reported that upon heating the macerated frozen tissue to 40 C. and adjusting the reaction to about pH 7.0 by dissolving disodium phosphate salt, and clarifying the juice by filtration, crystallization of the protein comes about during the gradual change of reaction from about pH 7.0 to 6.0 and cooling of the filtrate to room temperature. By adjusting the reaction to pH 4.5 (green to bromecresolgreen) with acetic or sulfuric acid, salting out with 0.3 saturation of ammonium sulfate and storage at 0 to 5 C. over night, further crystallization comes about.

Initial crystallization of the virus protein was obtained in the crude infectious tobacco juice by heating the frozen macerated green tissue to 40 C. for 10 minutes in presence of disodium phosphate salt (35.8 grams per 1,000 grams of green tissue); pressing the liquid through doubled cheesecloth by wringing with the hands; filtering this liquid through celite (25 grams per 1 liter of liquid); allowing the reaction of the filtrate to change without further treatment for 30 minutes (from about pH 7.0 to pH 6.0); adjusting the reaction to pH 4.5 with acetic or sulfuric acid; and dissolving ammonium sulfate to 0.3 saturation (175 gms per liter). Upon agitation the solution possessed a velvety appearance (sheen) which is considered characteristic of crystalline protein in suspension. The crystals developed rapidly and were similar to those illustrated by Stanley.[2] The material was allowed to stand over night at 0 to 5 C. before separation of the crystals from the liquid and subsequent recrystallization by three procedures:

Procedure A. Filtration and dissolving the crystals in alkaline phosphate buffer at pH 8.0 and 40 C. A 1,000 mls sample of the material (first crystallization) was filtered through 25 grams of celite by suction. The residue was dissolved in 500 mls of 0.1 molar phosphate buffer at pH 8.0 and 40 C. and the celite removed by filtration through paper. The filtrate was adjusted to a reaction of pH 4.5 and ammonium sulfate added to 0.3 saturation as in the first crystallization. The procedure was repeated for the third crystallization.

Procedure B. Filtration and Stanley's[3] calcium oxide method for dissolving the crystals. A 1,000 mls sample of the material was filtered as in procedure A,

[1] F. C. Bawden and N. W. Pirie, *Proc. Royal Soc. London*, Ser. B, 123: 274–320, 1937.

[2] W. M. Stanley, *Phytopath.*, 26: 305–320, 1936.

[3] W. M. Stanley, *Jour. Biol. Chem.*, 115: 673–678, 1936.

but the residue was dissolved at room temperature in 500 mls of distilled water by adjusting the reaction to pH 8.0 with a 0.1 per cent. aqueous suspension of calcium oxide. The celite was removed and recrystallization brought about as in procedure A. Procedure B was followed for the third crystallization.

Procedure C. Centrifugation at 1,500 times gravity for 10 minutes with treatment of sediment (supernatant liquid decanted) as in procedure A. Procedure C was followed for the third crystallization.

Assay of virus infectivity by the local-lesion method on primary leaves of Scotia beans was made by Mr. H. H. McKinney. Primary leaves of 20 bean plants at a susceptible age were inoculated with a 10^{-4} dilution (in 0.1 molar phosphate buffer at pH 7.0) of each sample previously adjusted to 1 mgm of protein per 1 ml of solution (nitrogen analysis by microkjeldahl of the material precipitated by 5 per cent. trichloroacetic acid). The average number of lesions per leaf was 4.2; 8.1; 4.4; 4.9; and 4.3 for the cheesecloth filtrate; celite filtrate of the crude juice; and the dissolved material from the third crystallization by procedures A, B and C, respectively. Infectivity of the material of the first or second crystallization was not determined.

These infectivity data based upon the protein content of each sample show no marked change in activity upon crystallizing the protein three times by either of the three procedures. The increase in infectivity of the celite filtrate, if significant, may have been due to particles of the celite in the liquid aiding infection or to filtration increasing the infectivity possibly by increasing the dispersion of the virus or removing some inhibitor. The increase is in agreement with that reported[4] from filtering crude juice in 0.1 molar phosphate buffer at pH 8.5 through Berkefeld "W" candles.

Tobacco juice from healthy plants when treated in a similar manner failed to develop any evidence of crystalline protein. The precipitate that formed was composed of amorphous material as far as could be determined microscopically.

H. H. THORNBERRY

BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

PHOTOPERIODIC STIMULUS TRANSFER IN PLANTS

IN experiments to determine the perceptive locus and mode of transfer of photoperiodic stimuli in plants, investigators have commonly used grafts of flowering scions upon vegetative stocks or *vice versa.*[1,2,3] Such entire grafted plants under a vegetative photoperiod have shown transfer of the residual flowering stimulus across the graft union, presumably in the form of a hormone, tentatively designated florigen.

These techniques are open to the objections that they introduce the extraneous stimulus of severe traumatism, result in considerable mortality, necessitate prolonged post-operative care, and interfere with nutrition. They are tedious, entail delay with its attendant hazards and inconvenience, and to a great degree they impose such severe numerical limitations as to preclude statistical evaluation of results. The photoperiodic responses also vary with the type of graft employed.

In order to minimize these difficulties, while at the same time differentially illuminating contiguous parts of the same plant, the writer has employed a thin, opaque panel with an adjustable, horizontal slit through which the tops of potted plants are trained from both sides as they grow under a vegetative photoperiod. At the desired time, short-day lighting is initiated on one side and long day on the other, thereby keeping the bases of one set vegetative and inducing flowering of the tops of the same plants, while the reciprocal responses are simultaneously induced in the other set on the opposite side of the panel. During the spring and summer, the daylight period can be shortened by use of a curtain suspended from a wire frame on the panel. Simpler, however, is the performance of the experiment under natural conditions of short day with extension of illumination for several hours by use of automatically timed, adjustable electric lights on the long-day side of the panel. Undesired reflection on the short-day side can readily be prevented by sufficient height and length of the panel. The slit panel technique is especially convenient when an interchange of lighting on opposite sides is desired, as it can be reversed without moving the plants.

The panel procedure yields more consistent results and hence makes interpretations simpler which, in combination with larger experimental populations, adds an important element of reliability. In an investigation on dioecious plants the writer has found the functional and structural responses of staminate parts to be distinctly different from those of pistillate parts to a given photoperiod, when top and base of the same plant are subjected to contrasted length of day. In other words, the reproductive photoperiod both in long- and short-day species exerts a different effect upon the "male" and "female" processes, a response which may permit the elucidation of many as yet ob-

[4] H. H. Thornberry, *Phytopath.*, 25: 618–627, 1935.

[1] M. C. Cajlachjan and L. M. Yarkovaja, *C. R. Acad. Sci. URSS*, 15: pp. 215–217, 1937. Also pp. 85–88; 3: pp. 443–447; and 4: pp. 77–81, 1936.

[2] B. S. Moskov, *C. R. Acad. Sci. URSS*, 15: pp. 211–213, 1937.

[3] J. Kuijper and L. K. Wiersum, *Proc. Acad. Sci. Amsterdam*, 39: pp. 1114–1122, 1936.

scure points in our knowledge of sex differentiation, especially as this involves the early phases controlled by the so-called asexual sporophyte. The slit panel technique, combined with various types of experimental defoliation and exfloration, reveals striking species differences in photoperiodic response.

W. F. Loehwing

University of Iowa

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE DETERMINATION OF SEDIMENTATION RATE AND EQUILIBRIUM IN CENTRIFUGES AND OPAQUE ULTRACENTRIFUGES

The great importance of the ultracentrifuge as developed by Svedberg and his collaborators at Uppsala is universally recognized, whether for applications in colloid science, in biology, in medicine or in industry. Such equipment has, in spite of its extreme costliness, been installed in a number of laboratories outside Sweden; and similar transparent rotors, run *in vacuo*, although still distinctly expensive, are being used at several other centers. A less expensive but smaller transparent ultracentrifuge has been developed in the author's laboratory.[1]

It may not be generally realized[2] that there now exists for every laboratory a choice of methods using either commercial centrifuges or still less expensive air-driven ultracentrifuges. With these, quantitative measurements may be made of particle size or molecular weight for every kind of solution or of suspension. They possess the great advantage that the substances or materials measured are withdrawn for direct chemical or physical analysis, or for estimation by biological inoculation, etc.

The descriptions of these various methods are scattered through journals in quite different fields of science, and it is worth while to list them here. There are three differing groups of procedures. The first permits or encourages convection of the whole or of a large part of the liquid. In the second, the sedimenting liquid is immobilized within a jelly or gel, and in the third the sedimentation takes place within narrow spaces mechanically shielded from convection. These methods have yielded quantitative measurements of the rate of sedimentation, sedimentation equilibrium and actual density of suspended or dissolved particles.[3] The results are in good agreement with each other and with measurements made with the transparent ultracentrifuge including that of Elford using scattered light, and also with the less accurate but definite results given by the method of ultrafiltration.

The first method, the Bechhold-Schlesinger convective procedure, was originated in 1931,[4] and during the following years various qualitative and semi-quantitative observations of its occurrence were made in the author's laboratory at Stanford, in that of Beams at Virginia, and also by Gratia in Belgium, using the simplest form of one piece hollow rotor of Henriot and Huguenard.[5] This simple equipment is unsurpassed for centrifugal force and costs only a few dollars. Although admitting of quantitative results, in this form it is not an ultracentrifuge, for it is an essential in the latter that convection be eliminated in the liquid actually studied. A simple modification has yielded quantitative results, in the Middlesex Hospital, for sedimentation velocity[6] of bacteria, viruses, phages and oxy-hemoglobin, and for their specific gravity. For example, McIntosh and Selbie obtained a diameter of 56 Å for oxy-hemoglobin, identical with that quoted from Svedberg.

The method of immobilization by a jelly was introduced by McBain and Stuewer[7] and was first applied to the measurement of rate of sedimentation of the jelly structure itself. With 0.3 per cent. agar jelly, it gave the same sedimentation rate (65×10^{-13}) as was given (63×10^{-13}) by the transparent ultracentrifuge of McBain and O'Sullivan. Swelling pressures of the jelly were also measured. Soap curd has been used in the measurement of sedimentation equilibrium of sucrose.[8] We found that the theoretical sedimentation equilibrium is attained. On the other hand, the rate of sedimentation of hemoglobin is retarded. Dilute agar jelly has been used in the National Institute for Medical Research, London,[9] to convert the Sharples Super-Centrifuge into a convectionless ultracentrifuge. Five cc of virus solution gelatinized with dilute agar lines the closed bowl to a depth of 0.18 mm. Another 5 cc is then added and

[1] J. W. McBain and C. O'Sullivan, *Jour. Am. Chem. Soc.*, 57: 780, 1935; *ibid.*, 2631–41; and J. W. McBain, *ibid.*, 58: 2652, 1936.

[2] *Cf.* reference 11.

[3] Such densities are measured by altering that of the medium and observing the effect upon sedimentation; J. W. McBain, *Jour. Am. Chem. Soc.*, 58: 315–17, 1936; many examples in later references, for example, McIntosh and Selbie, 1937.

[4] H. Bechhold and M. Schlesinger, *Biochem. Zeit.*, 236: 392, 1931; *Zeit. Hygiene*, 112: 668, 1931; *ibid.*, 115: 342 and 354, 1933; *Phytopath. Zeit.*, 6: 627, 1933; M. Schlesinger, *Zeit. Hygiene*, 114: 161, 1932; *Biochem. Zeit.*, 264: 6–12, 1933; *Kolloid-Zeit.*, 67: 135, 1934; *Biodynamica*, 1935, 1.

[5] *C. R. Acad. Sci.*, 180: 1389, 1925; *Jour. Phys. Radium*, 8: 433, 1927.

[6] J. McIntosh, *Jour. Path. and Bact.*, 41: 215, 1935; J. McIntosh and F. R. Selbie, *Brit. Jour. Exp. Path.*, 18: 162–174, 1937.

[7] J. W. McBain and R. F. Stuewer, *Kolloid-Zeit.*, 74: 10–16, 1936.

[8] J. W. McBain and C. Alvarez-Tostado, *Nature*, 139: 1066, June, 1937, and *Jour. Am. Chem. Soc.*, 59: 2489, 1937.

[9] M. Schlesinger, *Nature*, 138: 549, 1936; M. Schlesinger and I. A. Galloway, *Jour. Hygiene*, 37: 445 and 463, 1937.

the film is so thin that convection does not occur, thus allowing both rate and equilibrium to be measured. Virus of foot-and-mouth disease is measured after three minutes. An antibody required only 30 minutes for sedimentation equilibrium. It is necessarily assumed that the agar jelly is of such concentration that it neither swells nor sediments. This, however, can be verified by direct experiment and adjusting the concentration of agar to the requisite value. Any influence of the agar on the absolute rate has to be tested by comparison in some other ultracentrifuge. Sedimentation equilibrium is of course unaffected.

The third method is to prevent convection by simple mechanical design. It is most general because the solution is uncontaminated in any way, and it is equally good for aqueous and non-aqueous systems. It also ranges equally well from the smallest molecules to the largest particles. Elford[10] described such a method for comparatively large particles such as phage or virus, avoiding convection by using an inverted glass, silica or metal tube, 1, 2 or 3 mm in internal diameter, immersed in a commercial or Henriot and Huguenard centrifuge. The particles settle within the tube with an undisturbed boundary, and before this reaches the outer opening of the tube the contents are analyzed. The position of the boundary may sometimes be followed by eye, using scattered or fluorescent light, and the results are fairly accurate. Many parallel holes in one block may be used to give larger volumes.

The author with Alvarez-Tostado has developed completely general methods for the quantitative study of sedimentation equilibrium and of sedimentation rate in mono-disperse or poly-disperse systems of any sort. The sedimentation equilibrium of sucrose[8] gave a molecular weight of 341 in exact agreement with the theoretical value, 342. The essential feature of these extremely simple air-driven ultracentrifuges is the use of a pile or piles of very thin plane horizontal annular rings or washers, with or without spacing pieces, to immobilize the whole or a part of the solution. For sedimentation equilibrium of any mono-disperse system, one pile is sufficient. For rate or for poly-disperse systems a number of concentric piles of these loose washers, each set held together by vertical pins fastened only to the top and bottom of the pile, are placed in the rotor so that after stopping the rotor each set can be lifted out and the contents analyzed to determine rate, equilibrium, true density and number of particle sizes. Another method which we had previously developed was to use piles of sectorial baffles built up horizontally like brick work, in the simplest one-piece metal rotor, obtaining successive portions of the liquid from between them by displacement with a heavier liquid put through a distributing plate while the rotor is running.

Lastly, Tiselius, Pedersen and Svedberg[11] have now put a partition of filter paper in the middle of their transparent ultracentrifuge cell so that an analysis is possible for determining the position of a single mono-disperse boundary.

A complete generalization of the mechanical method for rate of sedimentation is suggested by the author. It consists merely of a pile of horizontal circular solid disks, alternately wide and narrow, placed in the axis of a simple two-piece air-driven rotor. The small disks serve as spacing pieces for the larger ones between which the liquid is wholly immobilized, permitting ideal radial undisturbed sedimentation.

Particles or molecules of different sizes in the same fluid are detected and measured by varying the rate and extent of sedimentation in successive experiments.

In conclusion, it may be noted that even the Bechhold method may be used for distinguishing between mono-disperse and multi-disperse systems. It is easy to ascertain whether or not two substances are combined or associated with each other or sediment separately (as was done, for example, by Gratia in 1934).

It is evident that the problem of obtaining exact quantitative data on one or all of the quantities mentioned has been completely solved by simple means within the reach of every scientific laboratory.

JAMES W. MCBAIN

DEPARTMENT OF CHEMISTRY
STANFORD UNIVERSITY

[10] W. J. Elford, *Brit. Jour. Exp. Path.*, 17: 399, 1936; Elford and C. H. Andrewes, *ibid.*, 422; Elford and I. A. Galloway, *ibid.*, 18: 155, 1937; F. F. Tang, Elford and Galloway, *ibid.*, 269.

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